Stock Assessment and Fishery Evaluation Report
for the
KING AND TANNER CRAB FISHERIES
of the
Bering Sea and Aleutian Islands Regions

2017 Final Crab SAFE

Compiled by

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of the Bering Sea and Aleutian Islands

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September 2017

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Introduction

The annual stock assessment and fishery evaluation (SAFE) report is a requirement of the North Pacific Fishery Management Council's *Fishery Management Plan for Bering Sea/Aleutian Islands King and Tanner Crabs* (FMP), and a federal requirement [50 CFR Section 602.12(e)]. The SAFE report summarizes the current biological and economic status of fisheries, total allowable catch (TAC) or Guideline Harvest Level (GHL), and analytical information used for management decisions. Additional information on Bering Sea/Aleutian Islands (BSAI) king and Tanner crab is available on the National Marine Fisheries Service (NMFS) web page at http://www.fakr.noaa.gov and the Alaska Department of Fish and Game (ADF&G) Westward Region Shellfish web page at: http://www.cf.adfg.state.ak.us/region4/shellfsh/shelhom4.php.

Paralithodes camtschaticus, stocks (Bristol Bay, Pribilof Islands, Norton Sound and Adak), 2 blue king crab, *Paralithodes platypus*, stocks (Pribilof Islands and St Matthew Island), 2 golden (or brown) king crab, *Lithodes aequispinus*, stocks (Aleutian Islands and Pribilof Islands), southern Tanner crab *Chionoecetes bairdi* hereafter referred to as Tanner crab, and snow crab *Chionoecetes opilio*. All other crab stocks in the BSAI are exclusively managed by the State of Alaska (SOA).

The Crab Plan Team (CPT) annually assembles the SAFE report with contributions from ADF&G and the NMFS. This SAFE report is presented to the North Pacific Fishery Management Council (NPFMC) and is available to the public on the NPFMC web page at:

http://fakr.noaa.gov/npfmc/membership/plan_teams/CRAB_team.htm.

Due to a process to accommodate specific fishery and data availability needs to determine overfishing level (OFL) determinations, and annual catch limit (ACL) requirements, the CPT reviews assessments in a staggered time frame. Additionally, based upon consideration of stock prioritization including assessment methods and data availability, some stocks are assessed on an annual basis while others are assessed less frequently. The CPT reviews one assessment in January (Norton Sound red king crab), two assessments in May on a three-year cycle (WAI red king crab and Pribilof Islands golden king crab) and the remaining assessments (Bristol Bay red king crab, EBS snow crab, EBS Tanner crab, Saint Matthew blue king crab, Pribilof Island red king crab and Pribilof Island blue king crab, Aleutian Islands golden king crab,) in September (Table 1). Pribilof red king crab is assessed biennially while Pribilof blue king crab is assessed on a three-year cycle. Stocks can be assessed more frequently on a case-by-case basis should data indicate that it is necessary.

Table 1 Ten BSAI crab stocks: Schedule for review by the CPT and SSC and Assessment frequency

Stock	*CPT review and recommendations to SSC*	*SSC review and recommendations to Council*	*Assessment frequency*	*Year of next Assessment*
Norton Sound red king crab (NSRKC)	January	February	Annual	2018
Aleutian Is. golden king crab (AIGKC)	May	June	Annual	2018
Pribilof Is. golden king crab (PIGKC)	May	June	Triennial	2020
Western Aleutian Is. red king crab (WAIRKC)	May	June	Triennial	2020
EBS snow crab	September	October	Annual	2018
Bristol Bay red king crab(BBRKC)	September	October	Annual	2018
EBS Tanner crab	September	October	Annual	2018
Pribilof Is. red king crab (PIRKC)	September	October	Biennial	2019
Pribilof Is. blue king crab (PIBKC)	September	October	Triennial	2020
Saint Matthew blue king crab (SMBKC)	September	October	Annual	2018

Based upon the assessment frequency described in Table 1, the CPT provides recommendations on OFL, acceptable biological catch (ABC) and stock status specifications for review by the NPFMC Science and Statistical Committee (SSC) in February (NSRKC) and June (WAIRKC, PIGKC) and October (BBRKC, EBS Snow crab, EBS Tanner crab, SMBKC, PIRKC, PIBKC, AIGKC). The rationale for this staggered review process is the following: The stocks with summer fisheries as well as those established on catch data only have specifications set in June. The stocks which employ data from the EBS NMFS trawl survey thus cannot be assessed until survey data are available in early September. Summer catch data for NSRKC however are not available in time for fall specifications, nor is assessing this stock with the June timing feasible as the CDQ fishery can open as early as May thus this stock is assessed in the winter. Additional information on the OFL and ABC determination process is contained in this report.

The CPT met from September 18-21, 2017 in Seattle, WA to review the final stock assessments as well as additional related issues, in order to provide the recommendations and status determinations contained in this SAFE report. This final 2017 Crab SAFE report contains all recommendations for all 10 stocks including those whose OFL and ABC were previously determined in February and June 2017. This SAFE report will be presented to the NPFMC in October for their annual review of the status of BSAI Crab stocks. Members of the team who participated in this review include the following: Bob Foy (Chair), Karla Bush (Vice-Chair), Katie Pavlof, Miranda Westphal, Brian Garber-Yonts, Ginny Eckert, Krista Milani, André Punt, Buck Stockhausen, Ben Daly, Martin Dorn, Shareef Siddeek, Jack Turnock and Diana Stram.

Stock Status Definitions

The FMP (incorporating all changes made following adoption of Amendment 24) contains the following stock status definitions:

Acceptable biological catch (ABC) is a level of annual catch of a stock that accounts for the scientific uncertainty in the estimate of OFL and any other specified scientific uncertainty and is set to prevent, with a greater than 50 percent probability, the OFL from being exceeded. The ABC is set below the OFL.

ABC Control Rule is the specified approach in the five-tier system for setting the maximum permissible ABC for each stock as a function of the scientific uncertainty in the estimate of OFL and any other specified scientific uncertainty.

Annual catch limit (ACL) is the level of annual catch of a stock that serves as the basis for invoking accountability measures. For EBS crab stocks, the ACL will be set at the ABC.

Total allowable catch (TAC) is the annual catch target for the directed fishery for a stock, set to prevent exceeding the ACL for that stock and in accordance with section 8.2.2 of the FMP.

Guideline harvest level (GHL) means the preseason estimated level of allowable fish harvest which will not jeopardize the sustained yield of the fish stocks. A GHL may be expressed as a range of allowable harvests for a species or species group of crab for each registration area, district, subdistrict, or section.

Maximum sustainable yield (MSY) is the largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological and environmental conditions. MSY is estimated from the best information available.

F_{MSY} control rule means a harvest strategy which, if implemented, would be expected to result in a long-term average catch approximating MSY.

B_{MSY} stock size is the biomass that results from fishing at constant F_{MSY} and is the minimum standard for a rebuilding target when a rebuilding plan is required.

Maximum fishing mortality threshold (MFMT) is defined by the F_{OFL} control rule, and is expressed as the fishing mortality rate.

Minimum stock size threshold (MSST) is one half the B_{MSY} stock size.

Overfished is determined by comparing annual biomass estimates to the established MSST. For stocks where MSST (or proxies) are defined, if the biomass drops below the MSST (or proxy thereof) then the stock is considered to be overfished. For crab stocks, biomass for determining overfished status is estimated on February 15 of the current year and compared to the MSST established by the NPFMC in October of the previous year.

Overfishing is defined as any amount of catch in excess of the overfishing level (OFL). The OFL is calculated by applying abundance estimates to the F_{OFL} control rule which is annually estimated according the tier system (see Chapter 6.0 in the FMP).

Status Determination Criteria

The FMP defines the following status determination criteria and the process by which these are defined following adoption of Amendment 24 and 38.

Status determination criteria for crab stocks are calculated using a five-tier system that accommodates varying levels of uncertainty of information. The five-tier system incorporates new scientific information and provides a mechanism to continually improve the status determination criteria as new information becomes available. Under the five-tier system, overfishing and overfished criteria and ABC levels for most stocks are annually formulated. The ACL for each stock equals the ABC for that stock. Each crab stock is annually assessed to determine its status and whether (1) overfishing is occurring or the rate or level of fishing mortality for the stock is approaching overfishing, (2) the stock is overfished or the stock is approaching an overfished condition, and (3) the catch has exceeded the ACL.

For crab stocks, the OFL equals the maximum sustainable yield (MSY) and is derived through the annual assessment process, under the framework of the tier system. Overfishing is determined by comparing the OFL with the catch estimates for that crab fishing year. For the previous crab fishing year, NMFS will determine whether overfishing occurred by comparing the previous year's OFL with the catch from the previous crab fishing year. For the previous crab fishing year, NMFS will also determine whether the ACL was exceeded by comparing the ACL with the catch estimates for that crab fishing year. Catch includes all fishery removals, including retained catch and discard losses, for those stocks where non-target fishery removal data are available. Discard losses are determined by multiplying the appropriate handling mortality rate by observer estimates of bycatch discards. For stocks where only retained catch information is available, the OFL and ACL will be set for and compared to the retained catch.

The NMFS will determine whether a stock is in an overfished condition by comparing annual biomass estimates to the established MSST. For stocks where MSST (or proxies) are defined, if the biomass drops below the MSST (or proxy thereof) then the stock is considered to be overfished. MSSTs or proxies are set for stocks in Tiers 1-4. For Tier 5 stocks, it is not possible to set an MSST because there are no reliable estimates of biomass.

If overfishing occurred or the stock is overfished, section 304(e)(3)(A) of the Magnuson-Stevens Act, as amended, requires the NPFMC to immediately end overfishing and rebuild affected stocks.

The Magnuson-Stevens Act requires that FMPs include accountability measures to prevent ACLs from being exceeded and to correct overages of the ACL if they do occur. Accountability measures to prevent TACs and GHLs from being exceeded have been used under this FMP for the management of the BSAI crab fisheries and will continue to be used to prevent ACLs from being exceeded. These include: individual fishing quotas and the measures to ensure that individual fishing quotas are not exceeded, measures to minimize crab bycatch in directed crab fisheries, and monitoring and catch accounting measures. Accountability measures in the harvest specification process include downward adjustments to the ACL and TAC in the fishing year after an ACL has been exceeded.

Annually, the NPFMC, SSC, and CPT will review (1) the stock assessment documents, (2) the OFLs and ABCs, and TACs or GHLs, (3) NMFS's determination of whether overfishing occurred in the previous crab fishing year, (4) NMFS's determination of whether any stocks are overfished and (5) NMFS's determination of whether catch exceeded the ACL in the previous crab fishing year.

Optimum yield is defined in Chapter 4 of the FMP. Information pertaining to economic, social and ecological factors relevant to the determination of optimum yield is provided in several sections of the FMP, including sections 7.2 (Management Objectives), Chapter 11, Appendix D (Biological and Environmental Characteristics of the Resource), and Appendix H (Community Profiles).

For each crab fishery, the optimum yield range is 0 to < OFL catch. For crab stocks, the OFL is the annualized MSY and is derived through the annual assessment process, under the framework of the tier system. Recognizing the relatively volatile reproductive potential of crab stocks, the cooperative management structure of the FMP, and the past practice of restricting or even prohibiting directed harvests of some stocks out of ecological considerations, this optimum yield range is intended to facilitate the achievement of the biological objectives and economic and social objectives of the FMP (see sections 7.2.1 and 7.2.2) under a variety of future biological and ecological conditions. It enables the SOA to determine the appropriate TAC levels below the OFL to prevent overfishing or address other biological concerns that may affect the reproductive potential of a stock but that are not reflected in the OFL itself. Under FMP section 8.2.2, the SOA establishes TACs at levels that maximize harvests, and associated economic and social benefits, when biological and ecological conditions warrant doing so.

Five-Tier System

The OFL and ABC for each stock are estimated for the upcoming crab fishing year using the five-tier system, detailed in Table 6-1 and 6-2. First, a stock is assigned to one of the five tiers based on the availability of information for that stock and model parameter choices are made. Tier assignments and model parameter choices are recommended through the CPT process to the SSC. The SSC recommends tier assignments, stock assessment and model structure, and parameter choices, including whether information is "reliable," for the assessment authors to use for calculating the proposed OFLs and ABCs based on the five-tier system.

For Tiers 1 through 4, once a stock is assigned to a tier, the determination of stock status level is based on recent survey data and assessment models, as available. The stock status level determines the equation used in calculating the F_{OFL}. Three levels of stock status are specified and denoted by “a,” “b,” and “c” (see Table 6-1). The F_{MSY} control rule reduces the F_{OFL} as biomass declines by stock status level. At stock status level “a,” current stock biomass exceeds the B_{MSY}. For stocks in status level “b,” current biomass is less than B_{MSY} but greater than a level specified as the “critical biomass threshold” (β).

In stock status level “c,” the ratio of current biomass to B_{MSY} (or a proxy for B_{MSY}) is below β. At stock status level “c,” directed fishing is prohibited and an F_{OFL} at or below F_{MSY} would be determined for all other sources of fishing mortality in the development of the rebuilding plan. The Council will develop a rebuilding plan once a stock level falls below the MSST.

For Tiers 1 through 3, the coefficient α is set at a default value of 0.1, and β set at a default value of 0.25, with the understanding that the SSC may recommend different values for a specific stock or stock complex as merited by the best available scientific information.

In Tier 4, a default value of natural mortality rate (M) or an M proxy, and a scalar, γ, are used in the calculation of the F_{OFL}.

In Tier 5, the OFL is specified in terms of an average catch value over an historical time period, unless the SSC recommends an alternative value based on the best available scientific information.

Second, the assessment author prepares the stock assessment and calculates the proposed OFLs by applying the F_{OFL} and using the most recent abundance estimates. The assessment authors calculate the proposed ABCs by applying the ABC control rule to the proposed OFL.

Stock assessment documents shall:

- use risk-neutral assumptions;
- specify how the probability distribution of the OFL used in the ABC control rule is calculated for each stock; and
- specify the factors influencing scientific uncertainty that are accounted for in calculation of the probability distribution of the OFL.

Second, the CPT annually reviews stock assessment documents, the most recent abundance estimates, the proposed OFLs and ABCs, and complies the SAFE. The CPT then makes recommendations to the SSC on the OFLs, ABCs, and any other issues related to the crab stocks.

Third, the SSC annually reviews the SAFE report, including the stock assessment documents, recommendations from the CPT, and the methods to address scientific uncertainty.

In reviewing the SAFE, the CPT and the SSC shall evaluate and make recommendations, as necessary, on:

- the assumptions made for stock assessment models and estimation of OFLs;
- the specifications of the probability distribution of the OFL;
- the methods to appropriately quantify uncertainty in the ABC control rule; and
- the factors influencing scientific uncertainty that the SOA has accounted for and will account for on an annual basis in TAC setting.

The SSC will then set the final OFLs and ABCs for the upcoming crab fishing year. The SSC may set an ABC lower than the result of the ABC control rule, but it must provide an explanation for setting the ABC less than the maximum ABC.

As an accountability measure, the total catch estimate used in the stock assessment will include any amount of harvest that may have exceeded the ACL in the previous fishing season. For stocks managed under Tiers 1 through 4, this would result in a lower maximum ABC in the subsequent year, all else being equal, because maximum ABC varies directly with biomass. For Tier 5 stocks, the information used to establish the ABC is insufficient to reliably estimate abundance or discern the existence or extent of biological consequences caused by an overage in the preceding year. Consequently, the subsequent year's maximum ABC will not automatically decrease. However, when the ACL for a Tier 5 stock has been exceeded, the SSC may decrease the ABC for the subsequent fishing season as an accountability measure.

Tiers 1 through 3

For Tiers 1 through 3, reliable estimates of B, B_{MSY}, and F_{MSY}, or their respective proxy values, are available. Tiers 1 and 2 are for stocks with a reliable estimate of the spawner/recruit relationship, thereby enabling the estimation of the limit reference points B_{MSY} and F_{MSY}.

- Tier 1 is for stocks with assessment models in which the probability density function (pdf) of F_{MSY} is estimated.
- Tier 2 is for stocks with assessment models in which a reliable point estimate, but not the pdf, of F_{MSY} is made.
- Tier 3 is for stocks where reliable estimates of the spawner/recruit relationship are not available, but proxies for F_{MSY} and B_{MSY} can be estimated.

For Tier 3 stocks, maturity and other essential life-history information are available to estimate proxy limit reference points. For Tier 3, a designation of the form "F_X" refers to the fishing mortality rate associated with an equilibrium level of fertilized egg production (or its proxy such as mature male biomass at mating) per recruit equal to X% of the equilibrium level in the absence of any fishing.

The OFL and ABC calculation accounts for all losses to the stock not attributable to natural mortality. The OFL and ACL are total catch limits comprised of three catch components: (1) non-directed fishery discard losses; (2) directed fishery discard losses; and (3) directed fishery retained catch. To determine the discard losses, the handling mortality rate is multiplied by bycatch discards in each fishery. Overfishing would occur if, in any year, the sum of all three catch components exceeds the OFL.

Tier 4

Tier 4 is for stocks where essential life-history, recruitment information, and understanding are insufficient to achieve Tier 3. Therefore, it is not possible to estimate the spawner-recruit relationship. However, there is sufficient information for simulation modeling that captures the essential population dynamics of the stock as well as the performance of the fisheries. The simulation modeling approach employed in the derivation of the annual OFLs captures the historical performance of the fisheries as seen in observer data from the early 1990s to present and thus borrows information from other stocks as necessary to estimate biological parameters such as γ.

In Tier 4, a default value of natural mortality rate (M) or an M proxy, and a scalar, γ, are used in the calculation of the F_{OFL}. Explicit to Tier 4 are reliable estimates of current survey biomass and the instantaneous M. The proxy B_{MSY} is the average biomass over a specified time period, with the understanding that the Council's Scientific and Statistical Committee may recommend a different value for a specific stock or stock complex as merited by the best available scientific information. A scalar, γ, is multiplied by M to estimate the F_{OFL} for stocks at status levels **"**a**"** and **"**b,**"** and γ is allowed to be less than or greater than unity. Use of the scalar γ is intended to allow adjustments in the overfishing definitions to account for differences in biomass measures. A default value of γ is set at 1.0, with the understanding that the Council's Scientific and Statistical Committee may recommend a different value for a specific stock or stock complex as merited by the best available scientific information.

If the information necessary to determine total catch OFLs and ACLs is available for a Tier 4 stock, then the OFL and ACL will be total catch limits comprised of three catch components: (1) non-directed fishery discard losses; (2) directed fishery discard losses; and (3) directed fishery retained catch. If the information necessary to determine total catch OFLs and ACLs is not available for a Tier 4 stock, then the OFL and ACL are determined for retained catch. In the future, as information improves, data would be available for some stocks to allow the formulation and use of selectivity curves for the discard fisheries (directed and non-directed losses) as well as the directed fishery (retained catch) in the models. The resulting OFL and ACL from this approach, therefore, would be the total catch OFL and ACL.

Tier 5

Tier 5 stocks have no reliable estimates of biomass and only historical catch data are available. For Tier 5 stocks, the OFL is set equal to the average catch from a time period determined to be representative of the production potential of the stock, unless the Scientific and Statistical Committee recommends an alternative value based on the best available scientific information. The ABC control rule sets the maximum ABC at less than or equal to 90 percent of the OFL and the ACL equals the ABC.

For Tier 5 stocks where only retained catch information is available, the OFL and ACL will be set for the retained catch portion only, with the corresponding limits applying to the retained catch only. For Tier 5 stocks where information on bycatch mortality is available, the OFL and ACL calculations could include

discard losses, at which point the OFL and ACL would be applied to the retained catch plus the discard losses from directed and non-directed fisheries.

Figure 1. Overfishing control rule for Tiers 1 through 4. Directed fishing mortality is 0 below β.

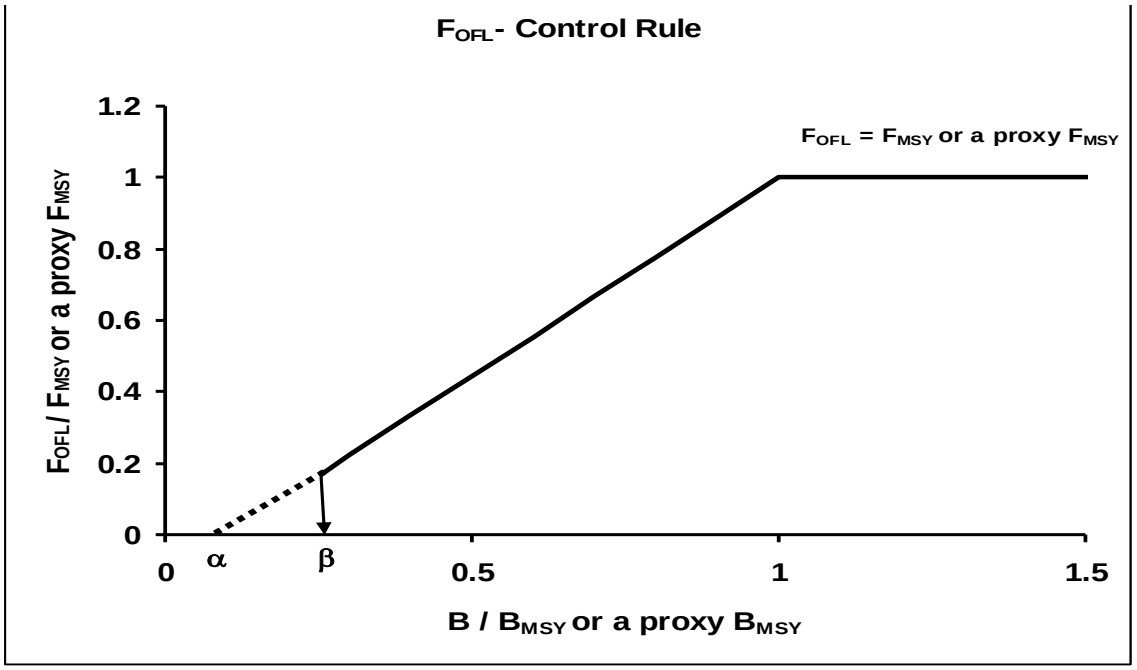

Table 1. Five-Tier System for setting overfishing limits (OFLs) and Acceptable Biological Catches (ABCs) for crab stocks. The tiers are listed in descending order of information availability. Table 2 contains a guide for understanding the five-tier system.

Information available	Tier	Stock status level	F_{OFL}	ABC control rule
B, B_{MSY}, F_{MSY}, and pdf of F_{MSY}	1	a. $\frac{B}{B_{msy}} > 1$	$F_{OFL} = \mu_A$ =arithmetic mean of the pdf	
		b. $\beta < \frac{B}{B_{msy}} \leq 1$	$F_{OFL} = \mu_A \frac{B/B_{msy} - \alpha}{1-\alpha}$	ABC≤(1-b_y) * OFL
		c. $\frac{B}{B_{msy}} \leq \beta$	Directed fishery F = 0 $F_{OFL} \leq F_{MSY}$†	
B, B_{MSY}, F_{MSY}	2	a. $\frac{B}{B_{msy}} > 1$	$F_{OFL} = F_{msy}$	
		b. $\beta < \frac{B}{B_{msy}} \leq 1$	$F_{OFL} = F_{msy} \frac{B/B_{msy} - \alpha}{1-\alpha}$	ABC≤(1-b_y) * OFL
		c. $\frac{B}{B_{msy}} \leq \beta$	Directed fishery F = 0 $F_{OFL} \leq F_{MSY}$†	
B, $F_{35\%}{}^{*}$, $B_{35\%}{}^{*}$	3	a. $\frac{B}{B_{35\%*}} > 1$	$F_{OFL} = F_{35\%}{}^{*}$	
		b. $\beta < \frac{B}{B_{35\%}{}^{*}} \leq 1$	$F_{OFL} = F^{*}{}_{35\%} \frac{\frac{B}{B^{*}{}_{35\%}} - \alpha}{1-\alpha}$	ABC≤(1-b_y) * OFL
		c. $\frac{B}{B_{35\%}{}^{*}} \leq \beta$	Directed fishery F = 0 $F_{OFL} \leq F_{MSY}$†	

Table continued on next page --

Table 1 (continued)

B, *M*, $B_{msy^{prox}}$	4	a. $\frac{B}{B_{msy^{prox}}} > 1$	$F_{OFL} = \gamma M$	
		b. $\beta < \frac{B}{B_{msy^{prox}}} \leq 1$	$F_{OFL} = \gamma M \frac{B/B_{msy^{prox}} - \alpha}{1-\alpha}$	ABC≤(1-b_y) * OFL
		c. $\frac{B}{B_{msy^{prox}}} \leq \beta$	Directed fishery F = 0 $F_{OFL} \leq F_{MSY}$†	
Stocks with no reliable estimates of biomass or M.	5		OFL = average catch from a time period to be determined, unless the SSC recommends an alternative value based on the best available scientific information.	ABC≤0.90 * OFL

*35% is the default value unless the SSC recommends a different value based on the best available scientific information.

† An $F_{OFL} \leq F_{MSY}$ will be determined in the development of the rebuilding plan for an overfished stock.

Table 2. A guide for understanding the five-tier system.

- F_{OFL} — the instantaneous fishing mortality (F) from the directed fishery that is used in the calculation of the overfishing limit (OFL). F_{OFL} is determined as a function of:
  - F_{MSY} — the instantaneous F that will produce MSY at the MSY-producing biomass
    - A proxy of F_{MSY} may be used; e.g., $F_{x\%}$, the instantaneous F that results in x% of the equilibrium spawning per recruit relative to the unfished value
  - B — a measure of the productive capacity of the stock, such as spawning biomass or fertilized egg production.
    - A proxy of B may be used; e.g., mature male biomass
  - B_{MSY} — the value of B at the MSY-producing level
    - A proxy of B_{MSY} may be used; e.g., mature male biomass at the MSY-producing level
  - β — a parameter with restriction that $0 \leq \beta < 1$.
  - α — a parameter with restriction that $0 \leq \alpha \leq \beta$.
- The maximum value of F_{OFL} is F_{MSY}. $F_{OFL} = F_{MSY}$ when $B > B_{MSY}$.
- F_{OFL} decreases linearly from F_{MSY} to $F_{MSY} \cdot (\beta-\alpha)/(1-\alpha)$ as B decreases from B_{MSY} to $\beta \cdot B_{MSY}$
- When $B \leq \beta \cdot B_{MSY}$, $F = 0$ for the directed fishery and $F_{OFL} \leq F_{MSY}$ for the non-directed fisheries, which will be determined in the development of the rebuilding plan.
- The parameter, β, determines the threshold level of B at or below which directed fishing is prohibited.
- The parameter, α, determines the value of F_{OFL} when B decreases to $\beta \cdot B_{MSY}$ and the rate at which F_{OFL} decreases with decreasing values of B when $\beta \cdot B_{MSY} < B \leq B_{MSY}$.
  - Larger values of α result in a smaller value of F_{OFL} when B decreases to $\beta \cdot B_{MSY}$.
  - Larger values of α result in F_{OFL} decreasing at a higher rate with decreasing values of B when $\beta \cdot B_{MSY} < B \leq B_{MSY}$.
- The parameter, b_y, is the value for the annual buffer calculated from a P* of 0.49 and a probability distribution for the OFL that accounts for scientific uncertainty in the estimate of OFL.
- P* is the probability that the estimate of ABC, which is calculated from the estimate of OFL, exceeds the "true" OFL (noted as OFL') (P(ABC>OFL').

Crab Plan Team Recommendations

Table 3 lists the team's recommendations for 2017/2018 on Tier assignments, model parameterizations, time periods for reference biomass estimation or appropriate catch averages, OFLs and ABCs. The team recommends four stocks be placed in Tier 3 (EBS snow crab, Bristol Bay red king crab, EBS Tanner crab and Aleutian Island golden king crab), four stocks in Tier 4 (St. Matthew blue king crab, Pribilof Islands blue king crab, Pribilof Islands red king crab, and Norton Sound red king crab) and two stocks in Tier 5 (Pribilof Islands golden king crab, and Adak red king crab). Table 4 lists those stocks for which the team recommends an ABC less than the maximum permissible ABC for 2017/18. Stock status in relation to status determination criteria are evaluated in this report (Table 5). Status of stocks in relation to status determination criteria for stocks in Tiers 3 and 4 are shown in Figure 2. EBS Tanner crab and Pribilof Island red king crab are estimated to be above B_{MSY} for 2017/18 while EBS snow crab, Bristol Bay red king crab, Saint Matthew blue king crab and Norton Sound red king crab are estimated below B_{MSY}. Pribilof Islands blue king crab stock remains overfished and estimated to be well below its MSST.

The CPT has general recommendations for all assessments and specific comments related to individual assessments. All recommendations are for consideration for the 2018 assessments. The general comments are listed below while the comments related to individual assessments are contained within the summary of CPT deliberations and recommendations contained in the stock specific summary section. Additional details regarding recommendations are contained in the Crab Plan Team Report (September 2017 CPT Report).

General recommendations for all assessments

1. The CPT recommends that all assessment authors document assumptions and simulate data under those assumptions to test the ability of the model to estimate key parameters in an unbiased manner. These simulations would be used to demonstrate precision and bias in estimated model parameters.
2. The CPT recommends that weighting factors be expressed as sigmas or CVs or effective sample sizes. The team requests all authors to follow the Guidelines for SAFE preparation and to follow the Terms of Reference as listed therein as applicable by individual assessment for both content and diagnostics.
3. Authors should focus on displaying information on revised models as compared to last year's model rather than focusing on aspects of the assessment that have not changed from the previous year.
4. The current approach for fitting length-composition data accounts for sampling error but ignores the fact that selectivity among size classes is not constant within years; a small change in the selectivity on small animals could lead to a very large change in the catch of such animals (as may have happened for NSRKC). Authors are encouraged to develop approaches for accounting for this source of process error. This issue is generic to assessments of crab and groundfish stocks.
5. Authors are reminded that assessments should include the time series of stock estimates at the time of survey for at least the author's recommended model in that year.
6. Consider stepwise changes to data as individual model runs instead of changing multiple parameters at once so that changes in model performance may be attributed to specific data

By convention the CPT used the following conversions to include tables in both lb and t in the status summary sections:

- million lb to 1000 t [/2.204624]
- 1000 t to million lb [/0.453592]

Stock Status Summaries

1 Eastern Bering Sea Snow crab

Fishery information relative to OFL setting

Total catch mortality in 2016/17 was 11,000 t (with discard mortality rates applied), while the retained catch in the directed fishery was 9,700 t. This was below the 2016/17 OFL of 23,700 t. Snow crab bycatch occurs in the directed fishery and to a lesser extent in the groundfish trawl fisheries. Estimates of trawl bycatch in recent years are less than 1% of the total snow crab catch. Estimates of stock status were above the B_{MSY} proxy for this stock ($B_{35\%}$) in 2010/11-2012/13, but below the B_{MSY} proxy more recently. For 2017/18, the ratio of projected MMB (99.6 t) fishing at the F_{OFL} to B_{MSY} (139,400 t) remains less than 1 but above 0.5.

Data and assessment methodology

The stock assessment is based on a size- and sex-structured model in which crabs are categorized into immature or mature and new or old shell. The model is fitted to abundance and size frequency data from the NMFS trawl survey, total catch data from the directed fishery, bycatch data from the trawl fishery, size frequency data for male retained catch in the directed fishery, and male and female bycatch in the directed and trawl fisheries. The model is also fitted to biomass estimates and size frequency data from the 2009 and 2010 BSFRF surveys. Updated data in the model include biomass and length frequency data from the 2017 NMFS Eastern Bering Sea trawl survey, retained and discard catch and length frequencies from the 2016/17 directed fishery, and discard catch and length frequencies from the 2016/17 groundfish fisheries.

The model estimation structure was similar to the 2016 assessment incorporating the status determination and OFL calculations directly within the model code which allowed the author to employ a Bayesian approach to determining OFL, by using Markov Chain Monte Carlo (MCMC) techniques to sample the posterior distributions of relevant quantities that more fully incorporated model uncertainty than was possible with the methods used previously. In this assessment, a jittering approach within a maximum likelihood framework was also used.

The assessment author examined eight model runs based on six model scenarios in this assessment. Model M16.D16 was equivalent to the September 2016 assessment model. Model M16.D17 included new survey data. Model M16.D17a dropped survey data prior to 1982 due to catchability coefficients prior to 1982 in spite of a smaller surveyed area. A larger model change was made in M17A.D17a to change the survey selectivity periods to before and after 1987 which is in line with the survey station distribution. M17Aa.D17a also included estimating the BSFRF data in logit space with a penalty because those parameters were hitting bounds. M17Ab.D17a was a separate model run provided in an appendix that considered the posterior distribution based on an alternate minimum of the likelihood function that produced bimodal management quantities. The results of this additional run differed substantially from the original run indicating that the posterior was not adequately sampled in either MCMC run based on M17Aa.D17a. Model M17B.D17a fit a straight line for growth removing data associated with the two smallest length bins. This model was not considered due to poor estimates of the probability of maturing and survey selectivity. Model M17C.D17a was recommended by the author and estimated M for females in addition to males and immature crab. All models except M17C.D17a had significant bimodal posterior distributions in reference points. The CPT concurred with the author recommended model M17C.D17a due to the large improvement in likelihood estimates and the lack of the bimodal posterior issues.

Stock biomass and recruitment trends

Survey mature male biomass based on a maturity ogive decreased from 167,100 t in 2011 to 97,500 t in 2013, increased to 163,500 t in 2014, fell to 63,200 t in 2016, and then increased to 83,960 t in 2017. The 2017 model estimates of mature male biomass showed trends similar to survey biomass during 2011–2017, except that the model failed to match the 1-year spike in survey biomass observed in 2014. Observed survey mature female biomass rose quickly from 52,200 t in 2009 to 175,800 t in 2011, its highest value since 1991, decreased steadily to 55,400 t in 2016, then increased to 106,800 t in 2017. Although the model matches the observed mature female survey biomass fairly well in 2016 and 2017, the model estimates do not follow the observed rise and fall that started in 2009; instead, they indicate that mature female biomass was fairly constant across the 2009–2016 time period. The model estimates a 3-year trend of increasing recruitment starting in 2014, with very high values for 2016 (> 6 million), and then decreases in 2017. This increase is supported by the associated NMFS EBS survey size compositions, particularly for males.

Tier determination/Plan Team discussion and resulting OFL/ABC determination Status and catch specifications

The CPT recommends that the EBS snow crab is a Tier 3 stock so the OFL will be determined by the F_{OFL} control rule using $F_{35\%}$ as the proxy for F_{MSY}. The proxy for B_{MSY} ($B_{35\%}$) is the mature male biomass at mating (139.4 thousand t) based on average recruitment over 1978 to 2017. Consequently, the minimum stock size threshold (MSST) is 69.7 thousand t. The CPT recommends that the ABC be less than maximum permissible ABC. The CPT recommends increasing the buffer previously used for snow crab (10%) to 20% for setting the 2017/18 ABC. The recommended increase is due to model uncertainties and contradictions between model trends and survey and fishery observations. In addition, model uncertainty is greater for 2017/18 because the chosen model had questionable selectivity estimates for mature females.

Historical status and catch specifications for snow crab (thousand t). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2013/14	71.5	126.5	24.5	24.5	28.1	78.1	70.3
2014/15	78.9	168.0	30.8	30.8	34.3	69.0	62.1
2015/16	75.8	91.6	18.4	18.4	21.4	83.1	62.3
2016/17	69.7	94.4	9.7	9.7	11.0	23.7	21.3
2017/18		99.6				28.4	22.7

Historical status and catch specifications for snow crab (million lb). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2013/14	157.6	279.0	54.0	54.0	62.0	172.2	155.0
2014/15	173.9	370.4	67.9	67.9	75.4	152.1	137.0
2015/16	167.1	201.9	40.6	40.6	47.2	183.2	137.4
2016/17	153.7	208.1	21.4	21.4	24.3	52.3	47.0
2017/18		219.6				62.6	50.1

2 Bristol Bay Red King Crab

Fishery information relative to OFL setting.

The commercial harvest of Bristol Bay red king crab (BBRKC) dates to the 1930s, and the fishery was initially prosecuted mostly by foreign fleets, but shifted to a largely domestic fishery in the early 1970s. Retained catch peaked in 1980 at 129.9 million lb (58.9 thousand t), but harvests dropped sharply in the early 1980s, and population abundance has remained at relatively low levels over the last two decades compared to those seen in the 1970s. The fishery is managed for a total allowable catch (TAC) coupled with restrictions for sex (males only), a minimum size for legal retention (6.5-in carapace width; 135-mm carapace length is used a proxy for 6.5-in carapace width in the assessment), and season (no fishing during mating/molting periods). In addition to the retained catch that occurs during the commercial fishery, which is limited by the TAC, there is also retained catch that occurs in the ADF&G cost-recovery fishery.

The current SOA harvest strategy allows a maximum harvest rate of 15% of mature-sized (≥120 mm CL) males, but also incorporates a maximum harvest rate of 50% of legal males and a threshold of 8.4 million mature-sized (≥90 mm CL) females and 14.5 million lb (6.6 thousand t) of effective spawning biomass (ESB), to prosecute a fishery. Annual non-retained catch of female and sublegal male RKC during the fishery averaged less than 3.9 million lb (8.6 thousand t) since data collection began in 1990. Total catch (retained and bycatch mortality) increased from 16.9 million lb (7.6 thousand t) in 2004/05 to 23.4 million lb (10.6 thousand t) in 2007/08, but has decreased since then; retained catch in 2016/17 was 8.64 million lb (3.92 thousand t) and total catch mortality was 9.44 million lb (4.28 thousand t).

Data and assessment methodology

The stock assessment is based on a sex- and size-structured population dynamics model incorporating data from the NMFS eastern Bering Sea trawl survey, the Bering Sea Fisheries Research Foundation (BSFRF) trawl survey, landings of commercial catch, at-sea observer sampling, and dockside retained catch sampling. In the model recommended by the CPT, annual stock abundance was estimated for male and female crabs ≥ 65-mm carapace length from 1975 to the time of the 2017 survey and mature male (males ≥120 mm CL) biomass was projected to 15 February 2018. Catch data (retained catch numbers, retained catch weight, and pot lifts by statistical area and landing date) from the directed fishery, which targets males ≥ 135 mm (6.5 in carapace length), were obtained from ADF&G fish tickets and reports, red king crab and Tanner crab fisheries bycatch data from the ADF&G observer database, and groundfish trawl bycatch data from the NMFS groundfish observer database. NMFS trawl survey data were updated with data from the 2017 survey and new estimates of survey variance provided by NMFS; catch and bycatch data were updated with data from the 2016/17 crab fishery year. The estimate of biomass from the BSFRF survey for 2016 was updated to reflect correction of a calculation error.

Three principal model scenarios were evaluated in the 2017 assessment: Scenario 2a, a minor revision to the Scenario 2 from the 2016 assessment, and two new model scenarios that 1) explored alternative ways to incorporate groundfish fisheries bycatch into the assessment (Scenario 2b) and 2) removed constraints on model parameters (Scenario 2d) . Scenario 2b was identical to scenario 2a, except that it separated bycatch of BBRKC in the groundfish fisheries by gear type (trawl and fixed) and fit these data using separate likelihood components. Scenario 2d was identical to 2b, but dropped the prior on trawl survey catchability from the double-bag experiment and used a logit transformation to ensure survey catchability was less than or equal to 1. The authors also evaluated the application of two approaches developed by Chris Francis to iteratively adjust the sample sizes applied to size composition data for each of the major alternative scenarios.

The CPT selected model 2b as its recommended model as the basis for status determination and OFL setting. The six model scenarios that included iterative re-weighting applied to size composition data (2a1, 2a2, 2b1, 2b2, 2d1, 2d2) were not selected because the iterative re-weighting resulted in greatly reduced effective sample sizes that led to problems with model convergence and parameter estimation. Scenario 2d implements the recommendation that the prior for survey catchability be removed because it only accounts for one factor impacting catchability. In particular, the prior ignores the impact of availability, which would be expected to reduce survey catchability. The BSFRF survey data suggest that the NMFS survey catchability is less than 1 (~0.6). However, Scenario 2d led to an estimate of survey catchability equal to the upper bound of 1 (and would have been even higher had the bound not been imposed). In addition, the uncertainty associated with the estimated parameter value was extremely large. Scenario 2d also under-predicted most of the BSFRF survey estimates while over-predicting most of the recent NMFS survey estimates. Although Scenario 2b also had an estimated value for NMFS survey catchability close to 1, it was lower than that for Scenario 2d and had a much smaller associated uncertainty. In addition, because the prior on NMFS survey catchability was informed by experimental results, it was felt that dropping the prior was equivalent to removing data from the assessment. The CPT speculates that the high NMFS survey catchability is a consequence of the model needing to replicate the rapid decline in survey abundance in the 1980s given the observed catches. Thus, the CPT selected Scenario 2b as its recommended model.

Stock biomass and recruitment trends

Model (scenario 2b) estimates of total survey biomass increased from 252 thousand t in 1975 to 297 thousand t in 1977, fell to 34.6 thousand t in 1985, generally increased to 91.9 thousand t in 2008, and subsequently declined to 60.3 thousand t in 2017. Estimated recruitment was high during the 1970s and early 1980s and has been generally low since 1985. The near-term outlook for this stock is a continued gradual declining trend. Recruitment has been poor (less than the mean from 1984-2016) since 2006. The 2011 survey produced a high catch of juvenile males and females <65 mm CL in one survey tow, but that catch did not track into the 2012−2017 surveys. The survey area-swept estimates for abundance and biomass in 2015-2017 were more consistent with previous surveys, in comparison to 2014, when the estimates were anomalously high.

Tier determination/Plan Team discussion and resulting OFL and ABC determination

Bristol Bay red king crab is in Tier 3. Based on the author's discussion regarding an apparent reduction in stock productivity associated with the 1976/77 climate regime shift in the EBS, the CPT recommends computing average recruitment as has been done in recent assessments (i.e., based on model recruitment using the time period 1984 (corresponding to fertilization in 1977) to the last year of the assessment) pending a more comprehensive discussion on this topic at the January 2018 CPT meeting. The estimated $B_{35\%}$ is 25.1 thousand t. MMB projected for 2017/18 is 21.31 thousand t, 85% of $B_{35\%}$. Consequently, the BBRKC stock is in Tier 3b in 2017/18.

The CPT recommends that the OFL for 2017/18 be set according to model scenario 2b, for which the calculated OFL is 5.60 thousand t (12.35 million lb). The team recommends that the ABC for 2017/18 be set below the maximum permissible ABC. The team recommends that a 10% buffer from the OFL be used to set the ABC at 5.04 thousand t (11.11 million lb).

MMB for 2016/17 was estimated to be 25.81 thousand t and above MSST (12.53 thousand t); hence the stock was not overfished in 2016/17. The total catch in 2016/17 (4.28 thousand t) was less than the 2016/17 OFL (6.64 thousand t); hence overfishing did not occur in 2016/17. The stock at 2017/18 time of mating is projected to be above the MSST and 85% of $B_{35\%}$ (see above); hence the stock is not approaching an overfished condition in 2017/18.

Historical status and catch specifications for Bristol Bay red king crab (thousand t). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2013/14	12.85	27.12	3.90	3.99	4.56	7.07	6.36
2014/15	13.03	27.25	4.49	4.54	5.44	6.82	6.14
2015/16	12.89	27.68	4.52	4.61	5.34	6.73	6.06
2016/17	12.53	25.81	3.84	3.92	4.28	6.64	5.97
2016/17		21.31				5.60	5.04

Historical status and catch specifications for Bristol Bay red king crab (million lb). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2013/14	28.3	59.9	8.60	8.80	10.05	15.58	14.02
2014/15	28.7	60.1	9.99	10.01	11.99	15.04	13.53
2015/16	28.4	61.0	9.97	10.17	11.77	14.84	13.36
2015/16	27.6	56.9	8.47	8.65	9.45	14.63	13.17
2016/17		47.0				12.35	11.11

3 Eastern Bering Sea Tanner crab

Fishery information relative to OFL setting.

Eastern Bering Sea (EBS) Tanner crab are caught in directed Tanner crab fisheries, as bycatch in the groundfish fisheries, scallop fisheries, as bycatch in the directed Tanner crab fishery (mainly as non-retained females and sublegal males), and other crab fisheries (notably, eastern Bering Sea snow crab and, to a lesser extent, Bristol Bay red king crab). A single OFL is set for Tanner crab in the EBS. Under the Crab Rationalization Program, ADF&G sets separate TACs for directed fisheries east and west of 166° W longitude. The mature male biomass was estimated to be below the Minimum Stock Size Threshold ($0.5B_{MSY}$) in February 2010 (the assumed time of mating) based on trends in mature male biomass from the survey, and NMFS declared the stock overfished in September 2010. The directed fishery was closed from 2010/11 through 2012/13 crab fishery years.

NMFS determined the stock was not overfished in 2012 based on a new assessment model with a revised estimate of B_{MSY}. The directed fishery was open for the 2013/14 to 2015/16 seasons with a total allowable catch (TAC) of 1,410 t in 2013/14, 6,850 t in 2014/15, and 8,920 t in 2015/16. The total retained catch in 2015/16 (8,910 t) was the largest taken in the fishery since 1992/93. In 2016/17, ADF&G determined that mature female biomass did not meet the criteria for opening a fishery according to the regulatory harvest strategy, and the TAC was set at zero. Consequently, there was no directed harvest in 2016/17.

Data and assessment methodology

The SSC accepted a size-structured assessment model for use in harvest specifications in 2012, and classified the EBS Tanner stock as a Tier 3 stock. This year's assessment used a new modeling framework, TCSAM02, which was endorsed by the SSC in June. TCSAM02 is similar to previous Tanner crab assessment models, but includes improvements to the modeling of fishery and population processes. The model is structured by crab size, sex, shell condition, and maturity. The model uses available data on quantity and size-composition from: the NMFS trawl survey; landings and discards by the directed fishery; bycatch in the Bristol Bay red king crab, EBS snow crab, and groundfish fisheries. The model includes prior distributions on parameters related to natural mortality and catchability, and penalties on changes in recruitment and in the proportion maturing. Input data sets were updated with the most recent information, including the NMFS EBS trawl survey in 2017; bycatch, and size composition data from the 2016/17 crab fisheries; and data on Tanner crab bycatch in the groundfish fisheries in 2016/17. A new data set was added which reflects Tanner crab growth in the eastern Bering Sea.

Stock biomass and recruitment trends

The MMB at the time of mating is estimated to have been highest early in the early 1970s (approximately 300 thousand t), with secondary peaks in 1989 (60 thousand t) and 2008–2009 (57–58 thousand t). The estimated MMB at time of mating in 2016/17 was 77.96 thousand t and the projection for the 2017/18 time of mating is 43.31 thousand t. Estimates of recruitment since 1999 have been generally low relative to the peaks estimated for the period prior to 1990. There was a relatively strong recruitment estimated for 2017, but this estimate is very uncertain and will need to be confirmed by subsequent assessments.

Tier determination/Plan Team discussion and resulting OFL and ABC determination

The CPT recommends the OFL for this stock be based on the Tier 3 control rule. Application of the Tier 3 control rule requires a set of years for defining R_{MSY}, the mean recruitment corresponding to B_{MSY} under prevailing environmental conditions. The recommended time period for defining R_{MSY} is 1982–2017; the 1982-and-onwards time period has been used in previous OFL determination and follows the most-recent recommendation of the SSC.

Based on the estimated biomass at 15 February 2017, the stock is at Tier 3 level a. The F_{MSY} proxy ($F_{35\%}$) is 0.75 yr^{-1}, and the 2017/18 F_{OFL} is 0.75 yr^{-1} under the Tier 3 level a OFL Control Rule, which results in a total male and female OFL of 25.42 thousand t. The CPT recommends a 20% buffer to account for model uncertainty and stock productivity uncertainty be applied to the OFL, to set ABC = 20.33 thousand t. The 20% buffer is the same that the SSC recommended for determination of the 2016/17 ABC.

Historical status and catch specifications for Eastern Bering Sea Tanner crab (thousand t). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	TAC (East + West)	Retained Catch	Total Catch Mortality	OFL	ABC
2013/14	16.98	72.70	1.41	1.26	2.78	25.35	17.82
2014/15	13.40	71.57	6.85	6.16	9.16	31.48	25.18
2015/16	12.82	73.93	8.92	8.91	11.38	27.19	21.75
2016/17	14.58	77.96	0.00	0.00	1.14	25.61	20.49
2017/18		43.31				25.42	20.33

Historical status and catch specifications for Eastern Bering Sea Tanner crab (million lb). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	TAC (East + West)	Retained Catch	Total Catch Mortality	OFL	ABC
2013/14	37.43	160.28	3.12	2.78	6.13	55.89	39.29
2014/15	29.53	157.78	15.10	13.58	20.19	69.40	55.51
2015/16	28.27	162.99	19.67	19.64	25.09	59.94	47.95
2016/17	32.15	171.87	0.00	0.00	2.52	56.46	45.17
2017/18		95.49				56.03	44.83

4 Pribilof Islands red king crab

Fishery information relative to OFL setting

The Pribilof Islands red king crab fishery began in 1973 as bycatch during the blue king crab fishery. In 1993 and 1994 the red king crab fishery was open to directed fishing, and blue king crab was closed. From 1995 through 1998, combined Pribilof Islands red and blue king crab GHLs were used. Declines in crab abundance of both red and blue king crab stocks from 1996 to 1998 resulted in poor fishery performance with annual harvests below the GHLs. The Pribilof red king crab fishery has been closed since 1999 due to uncertainty in estimated red king crab abundance and concerns for bycatch mortality of blue king crab, which is overfished and severely depressed. Fishery closures near the Pribilof Islands have resulted in low bycatch, recent bycatch has been well below the OFL, ranging from 0.32 to 13.1 t (<0.001 to 0.029 million pounds; 2012/13–2016/17).

Data and assessment methodology

The 2017 assessment is based on trends in male mature biomass (MMB) at the time of mating inferred from NMFS bottom trawl survey from 1975-2017 and commercial catch and observer data from 1973/74 to 2016/17. Two assessment methods using a Tier 4 harvest control rule were presented for evaluation: one calculated an annual index of MMB derived as the 3-yr running average using inverse variance weighting, and the second was a random effects model. The random effects model was presented with three variations: 1) λ fixed, 2) a prior on λ estimated from bootstrap (with CV=2.24) and 2) a prior on λ with CV 4.0.

Stock biomass and recruitment trends

Male and female abundance varies widely over the history of the survey time series and uncertainty around area-swept estimates of abundance are large due to relatively low sample sizes. Recruitment for this stock is generally low and episodic. Numbers at length vary dramatically from year to year; however, two (possibly three) cohorts can be seen moving through the length frequencies over time. MMB_{mating} increased over 2012 to 2016. Estimates for the 3-year moving average for MMB_{mating} in recent years approached those estimated during the early 1990s, peaking in 2014/15 at 9,963 t (21.96 million pounds).

Tier determination/Plan Team discussion and resulting OFL and ABC determination

The CPT recommended the Tier 4 stock status determination and selected the random effects model with a prior on λ estimated from a simple exponential model. A bootstrap analysis was used to obtain a prior CV=2.24. This model was selected because it is a better smoother of extreme survey values. For 2017/18 the B_{MSY} = 4,604 t (10.15 million pounds) derived as the mean MMB_{mating} from 1991/92 to 2016/17 from the random effects model. Male mature biomass at the time of mating for 2017/18 was estimated at 3,364 t (7.416 million pounds). The B/B_{MSY} = 0.73 and F_{OFL}= 0.13. $B/B_{MSY\ Proxy}$ is < 1, therefore the stock status level is Tier 4*b*. For the 2017/17 fishery, the OFL is 482 t (1.063 million lb). The CPT recommended a 25% buffer for an ABC from the OFL as in previous years.

Historical status and catch specifications for Pribilof Islands red king crab (t). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB_{mating})	TAC	Retained Catch	Total Catch	OFL	ABC
2013/14	2,582	4,679	0	0	2.25	903	718
2014/15	2,871	8,894	0	0	1.76	1,359	1,019
2015/16	2,756	9,062	0	0	0.32	2,119	1,467
2016/17	2,302	4,788	0	0	0.49	1,492	1,096
2017/18		3,364				482	362
2018/19						482	362

Historical status and catch specifications for Pribilof Islands red king crab (million lb). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2013/14	5.66	10.32	0	0	0.005	1.99	1.58
2014/15	6.33	19.61	0	0	0.002	3.00	2.25
2015/16	6.23	19.98	0	0	<0.001	4.67	3.23
2016/17	5.07	10.56	0	0	0.001	3.22	2.42
2017/18		7.42				1.06	0.80
2018/19						1.06	0.80

The stock was above MSST in 2016/17 and is hence not overfished. Overfishing did not occur during the 2016/17 fishing year.

5 Pribilof Islands blue king crab

Fishery information relative to OFL setting.

The Pribilof Islands blue king crab fishery began in 1973, with peak landings of 11.0 million lb during the 1980/81 season. A steep decline in landings occurred after the 1980/81 season. Directed fishery harvest from 1984/85 until 1987/88 was annually less than 1.0 million lb with low CPUE. The fishery was closed from 1988/89 through 1994/95 fishing seasons. The fishery reopened for the 1995/96 to 1998/99 seasons. Fishery harvests during this period ranged from 1.3 to 2.5 million lb. The fishery closed again for the 1999/00 season due to declining stock abundance and has remained closed to the present.

The stock was declared overfished in 2002 and a rebuilding plan implemented in 2004. The rebuilding plan closed directed fishing for Pribilof blue king crab until the stock was rebuilt. In 2009, NMFS determined the stock would not meet its 10-year rebuilding horizon. Subsequently, Amendment 43 to the King and Tanner Crab FMP and Amendment 103 to the BSAI Groundfish FMP were approved by the Secretary of Commerce in 2014. This action, a revised rebuilding plan, closed the Pribilof Island Habitat Conservation Zone to Pacific cod pot fishing, which accounts for the highest recent rates of bycatch of this stock. This area was already closed to groundfish trawl fishing. To prevent overfishing in the future, ADF&G will implement closure areas for the commercial crab fisheries to reduce the blue king crab bycatch. NMFS recently implemented a procedure to account for blue king crab bycatch in the groundfish fisheries inseason and will take inseason action to prevent overfishing.

Data and assessment methodology

The calculation of the 2017/18 survey biomass uses the stock area definition established in 2012/13 that includes an additional 20 nm strip east of the Pribilof District. This assessment uses the 2016/17 methodology to project MMB and calculate B_{MSY}. Prior to 2016/17, MMB for the current year was estimated from the NMFS EBS bottom trawl survey using a three-year running average weighted by the inverse of the variance of the area-swept estimate. The new methodology to calculate MMB and B_{MSY} was recommended by the CPT and uses a random effects model to smooth the survey time series. This model smooths the MMB estimates without low abundance estimates having undue influence. Differences in abundance estimates from the two methods were largest during periods of high inter-annual variability. Differences between the methods were small in recent years. Results from this method are shown starting with the 2015/16 MMB and 2016/2017 projected MMB.

Stock biomass and recruitment trends

The 2017/18 MMB at mating is projected to be 230 t, which is approximately 6% of the proxy for B_{MSY}. The Pribilof blue king crab stock biomass continues to be low with no indication of recruitment.

Tier determination/Plan Team discussion and resulting OFL and ABC determination

This stock is recommended for placement into Tier 4. B_{MSY} was estimated using the time periods 1980/81 - 1984/85 and 1990/91-1997/98. This range was chosen because it eliminates periods of extremely low abundance that may not be representative of the production potential of the stock. B_{MSY} is estimated at 4,108 t (9.06 million pounds) for 2017/18.

Because the projected 2017/18 estimate of MMB is less than 25% B_{MSY}, the stock is in stock status c and the directed fishery F is 0. However, an F_{OFL} must be determined for the non-directed catch. Ideally this should be based on the rebuilding strategy. For this stock, the F_{OFL} is based on average groundfish bycatch between 1999/00 and 2005/06. The recommended OFL for 2017/18 is 1.16 t (0.0026 million lb).

The CPT recommended setting the ABC less than the maximum permissible by employing a 25% buffer on the OFL. This recommendation was based upon continuing concerns with stock status and consistency with relative buffer levels for other stocks for which the OFL is based upon average catch.

Historical status and catch specifications for Pribilof Islands blue king crab (t). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2013/14	2,001	225	Closed	0	0.03	1.16	1.04
2014/15	2,055	344	Closed	0	0.07	1.16	0.87
2015/16	2,058	361	Closed	0	1.18	1.16	0.87
2016/17	2,054	232	Closed	0	0.38	1.16	0.87
2017/18		230				1.16	0.87
2018/19						1.16	0.87
2019/20						1.16	0.87

Historical status and catch specifications for Pribilof Islands blue king crab (million lb). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2013/14	4.411	0.496	Closed	0	0.0001	0.0026	0.002
2014/15	4.531	0.758	Closed	0	0.0002	0.0026	0.002
2015/16	4.537	0.796	Closed	0	0.0026	0.0026	0.002
2016/17	4.528	0.511	Closed	0	0.0008	0.0026	0.002
2017/18		0.507				0.0026	0.002
2018/19						0.0026	0.002
2019/20						0.0026	0.002

The total catch for 2016/17 (0.38 t, 0.0008 million lb) was less than the 2016/17 OFL (1.16 t, 0.0026 million lb) so overfishing did not occur during 2016/17. The 2017/18 projected MMB estimate of 230 t (0.507 million lb) is below the proxy for MSST (MMB/B_{MSY} = 0.06) so the stock is projected to continue to be in an overfished condition.

6 St. Matthew blue king crab

Fishery information relative to OFL setting

The fishery was prosecuted as a directed fishery from 1977 to 1998. Harvests peaked in 1983/84 when 4,288 t (9.453 million lb) were landed by 164 vessels. Harvest was fairly stable from 1986/87 to 1990/91, averaging 568 t (1.252 million lb) annually. Harvest increased to a mean catch of 1,496 t (3.298 million lb) during the 1991/92 to 1998/99 seasons until the fishery was declared overfished and closed in 1999 when the stock size estimate was below the MSST. In November of 2000, Amendment 15 to the FMP was approved to implement a rebuilding plan for the St. Matthew Island blue king crab stock. The rebuilding plan included a harvest strategy identified in regulation by the Alaska Board of Fisheries, an area closure to control bycatch, and gear modifications. In 2008/09 and 2009/10, the MMB was estimated to be above B_{MSY} for two years and the stock declared rebuilt in 2009.

The fishery re-opened in 2009/10 with a TAC of 529 t (1.166 million lb) and 209 t (0.461 million lb) of retained catch were harvested. The 2010/11 TAC was 726 t (1.601 million lb) and the fishery reported a retained catch of 573 t (1.263 million lb). The 2011/12 harvest of 853 t (1.881 million lb) represented 80% of the 1,152 t (2.540 million lb) TAC. In 2012/13, by contrast, harvesters landed 99% (733 t, 1.616 million lb) of a reduced TAC of 740 t (1.630 million lb), though fishery efficiency, at about 10 crab per pot, was little changed from what it had been in each of the previous three years. The directed fishery was closed in 2013/14 due to declining trawl survey estimates of abundance and concerns about the health of the stock. The directed fishery resumed again in 2014/15 with a TAC of 300 t (0.655 million pounds), but the fishery performance was relatively poor with the retained catch of 140 t (0.309 million pounds). The TAC in 2015/16 was 190 t (0.410 million pounds) with a retained catch of 47 t (0.105 million pounds). The fishery was closed in 2016/17. Bycatch of non-retained blue king crab has occurred in the St. Matthew blue king crab fishery, the eastern Bering Sea snow crab fishery, and trawl and fixed-gear groundfish fisheries. Based on limited observer data, bycatch of sublegal male and female crabs in the directed blue king crab fishery off St. Matthew Island was relatively high when the fishery was prosecuted in the 1990s, and total bycatch (in terms of number of crabs captured) was often twice as high or higher than total catch of legal crabs.

Data and assessment methodology

This assessment is conducted in the General Model for Alaska Crab Stocks (GMACS) framework, which was accepted for use by the CPT in May 2016 and the SSC in June 2016. This assessment differs from the original GMACS model in that natural and fishing mortality are continuous within 5 discrete seasons. In addition, the model estimates a dynamic B_0 computed as spawning biomass relative to spawning biomass if no fishing harvests had occurred. Season length in GMACS is controlled by changing the proportion of natural mortality that is applied during each season.

The GMACS assesses male crab ≥90 mm CL. The three length categories are: 90–104 mm CL; 105–119 mm CL; and ≥120 mm CL. Males ≥ 105 mm CL are used as a proxy for mature males, and males ≥120 mm CL are used as a proxy for legal males (≥5.5-inch carapace width). The model incorporates the following data: (1) commercial catch data from 1978/79–1998/99, 2009/10–2012/13, 2015/16; (2) annual trawl survey data from 1978 to 2017; (3) triennial pot survey data from 1995 to 2013 and annually from 2015 to 2017; (4) bycatch data in the groundfish trawl and groundfish fixed-gear fisheries from 1991 to 2016; and (5) ADF&G crab-observer composition data for the years 1990/91–1998/99, 2009/10–2012/13, 2014/15, and 2015/16.

The NMFS summer trawl survey data are from stations within the St. Matthew Island Section and comprise 56 stations compared to the 96 stations covered by the ADF&G pot survey. The pot surveys occur during July and August in areas of high-relief habitat important to blue king crab (particularly females) in areas

missed by the NMFS trawl survey. Groundfish discard information for trawl and fixed gear is derived from NMFS observer data for Bering Sea reporting areas 521 and 524.

Stock biomass and recruitment trends

Following a period of low values (~30% of the 1978-2017 mean of 5,762 t) after the stock was declared overfished in 1999, trawl-survey indices of stock abundance and biomass generally increased to well above average during 2007-2012. In 2013 survey biomass declined (~40% of the mean value) but was followed by average biomass estimates in 2014 and 2015, but with survey CVs of 77% and 45%, respectively). The 2016 survey biomass fell to 3,485 t (7.7 million lb with a CV of 39%), and the 2017 survey estimate declined again to 1,794 t (3.955 million lb, with a CV of 60%). This value represents 31% of the long term mean with the most recent 3-year average surveys at 65% of the historical mean. This suggests a general decline in biomass since 2010.

Because little information about the abundance of small crab is available for this stock, recruitment has been assessed in terms of the number of male crab within the 90-104 mm CL size class in each year. The 2017 trawl-survey area-swept estimate of 0.091 million males in this size class is the lowest in the 40-year time series since 1978 and only 9% of the long-term average recruitment. The 2017 abundance of this size group was also the second-lowest in the time series of the pot survey and 22% of the average.

Tier determination/Plan Team discussion and resulting OFL and ABC determination

The stock assessment examines 4 model configurations: (1) also referred to as the "reference case," the September 2016 model with the 2017 bottom trawl survey data and the 2017 pot survey data included; (2) VAST - a geo-spatial delta-GLMM application to the BTS data; (3) Fit survey - an exploratory scenario equivalent to the reference model except the NMFS trawl survey is up-weighted by 1.5 and the ADF&G pot survey is up-weighted by 2.0; and (4) Francis weights - similar to the reference model but with Francis' iterative re-weighting of the size-composition data. The assessment also evaluated reference model sensitivity to new survey data by running scenarios: (5) without the 2017 trawl survey or 2017 pot survey data included; and (6) with the trawl survey data included but without the pot survey data.

The CPT concurs with the author's recommendation to use the reference case model for the 2016/17 crab year. This stock is in Tier 4. The CPT recommended model uses the full assessment period (1978/79-2016/17) to define the proxy for B_{MSY} in terms of average estimated MMB_{mating}. The projected MMB estimated for 2017/18 under the recommended model is 2,180 t (4.806 million lb) and the F_{MSY} proxy is the natural mortality rate (0.18^{-1} year) and F_{OFL} is 0.079, resulting in a mature male biomass OFL of 123 t (0.273 million lb). The MMB/B_{MSY} ratio is 0.55. The author recommended and the CPT concurred with a 20% buffer on the OFL for the ABC which was consistent with the approach used last year. The ABC based on this buffer is 99 t (0.218 million lb).

Historical status and catch specifications for Saint Matthew blue king crab (thousand t). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB_{mating})	TAC	Retained Catch	Total Male Catch	OFL	ABC
2013/14	1.50	3.01	0.00	0.00	0.0003	0.56	0.45
2014/15	1.86	2.48	0.30	0.14	0.15	0.43	0.34
2015/16	1.84	2.11	0.19	0.05	0.05	0.28	0.22
2016/17	1.97	2.23	0.00	0.00	0.05	0.14	0.11
2017/18		2.18				0.12	0.10

Historical status and catch specifications for Saint Matthew blue king crab (million lb). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB_{mating})	TAC	Retained Catch	Total Male Catch	OFL	ABC
2013/14	3.4	6.64	0.00	0.00	0.0006	1.24	0.99
2014/15	4.1	5.47	0.655	0.309	0.329	0.94	0.75
2015/16	4.0	4.65	0.41	0.105	0.105	0.62	0.49
2016/17	4.30	4.91	0.00	0.000	0.000	0.31	0.25
2017/18		4.81				0.27	0.22

The stock was above MSST in 2016/17 and is hence not overfished. The total catch was less than the OFL in 2016/17 and hence overfishing did not occur.

7 Norton Sound Red King Crab

Fishery information relative to OFL setting

This stock supports three main fisheries: summer commercial, winter commercial, and winter subsistence. The summer commercial fishery, which accounts for the majority of the catch, reached a peak in the late 1970s at a little over 2.9 million pounds retained catch. Retained catches since 1982 have been below 0.5 million pounds, averaging 0.3 million pounds, including several low years in the 1990s. As the crab population rebounded, retained catches have increased to around 0.4 million pounds in recent years.

Data and assessment m*ethodology*

Four types of surveys have occurred periodically during the last three decades: summer trawl, summer pot, winter pot, and preseason summer pot, but none of these surveys have been conducted every year. The assessment is based on a male-only length-based model of male crab abundance that combines multiple sources of data. A maximum likelihood approach was used to estimate abundance, recruitment, and selectivity and catchability of the commercial pot gear. The model has been updated to include the following data: total catch, catch length composition, discard length composition data from the 2016 summer commercial fishery, and 2015/16 winter commercial and subsistence catch. In addition, the standardized commercial catch CPUE indices were updated to include data for 1977-2016 and the annual proportions of the commercial catch before the survey were recalculated based on fishticket data. The current model assumes a constant M=0.18yr^{-1} for all length classes except the > 134mm CL length-class, which had an estimated value of 0.590yr^{-1}. Logistic functions are used to describe fishery and survey selectivities, except for a dome-shaped function examined for the winter pot fishery.

The author summarized six model run alternatives, in conjunction with the 2016 base model (Model 0). The author recommended, and the CPT selected, Model 3 as the recommended configuration. This model estimated the molt probability for the 64-73mm CL length class. Other attributes were similar to the base model from the previous assessment. Model 3 fitted the compositional data better than the 2016 base model with one additional parameter.

Stock biomass and recruitment trends

Mature male biomass was estimated to be at an historic low in 1982 following a crash from the peak biomass in 1977. The MMB then exhibited an increase from a recent low in 1997 to a peak in 2010, before declining and then rebuilding. Estimated recruitment was weak during the late 1970s and high during the early 1980s, with a slight downward trend from 1983 to 1993. Estimated recruitment has generally been variable, with a slight increase in recent years.

Tier determination/Plan Team discussion and resulting OFL and ABC determination

The team recommended Tier 4, stock status a, for Norton Sound red king crab. The estimated abundance and biomass in 2016 using Model 3 are: Mature male biomass on Feb. 1: 5.14million lb (2.33 thousand t).

The $B_{MSY\ proxy}$, calculated as the average of mature male biomass on Feb. 1 during 1980-2017, was $B_{MSY\ proxy}$ = 4.62 million lb. The $F_{MSY\ proxy}$ is M =0.18 yr^{-1} and the F_{OFL}=0.18yr^{-1}, because the 2017 mature male biomass is larger than $B_{MSY\ proxy}$, with the CPT choosing the default of gamma =1.0.

The maximum permissible ABC would be 0.66 million lb, based on projected retained catch on July 1. The OFL is retained catch OFL although a total catch OFL is computed as part of the assessment. The CPT recommended an ABC less than the maximum permissible due to concerns with model specification, unresolved competing hypotheses about whether the lack of large animals in catches and surveys is due to higher mortality or migration from the area, lack of bycatch data as well as issues noted with the *M*

employed for the largest length group. The CPT recommended an ABC = 80% of the OFL (20% buffer) of 0.54 million lb.

Status and catch specifications (1000t). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	GHL	Retained Catch [1]	Total Catch [2]	Retained Catch OFL	Retained Catch ABC
2013/14	0.93	2.27	0.23	0.16	0.16	0.26	0.24
2014/15	0.96	1.68	0.17	0.18	0.18	0.21	0.19
2015	1.09	2.33	0.18	0.18	0.24	0.33	0.26
2016	1.03	2.66	0.24	0.23	0.24	0.32	0.26
2017	1.05	2.33	0.50	0.49	0.50	0.30	0.24

1: Summer commercial fishery.
2: Summer commercial fishery, winter commercial fishery and subsistence fishery.

Status and catch specifications (million lb.) Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

Year	MSST	Biomass (MMB)	GHL	Retained Catch [1]	Total Catch [2]	Retained Catch OFL	Retained Catch ABC
2013/14	2.06	5.00	0.50	0.35	0.35	0.58	0.52
2014/15	2.11	3.71	0.38	0.39	0.39	0.46	0.42
2015	2.41	5.13	0.39	0.40	0.52	0.72	0.58
2016	2.26	5.87	0.52	0.51	0.52	0.71	0.57
2017	2.31	5.14	0.23	0.22	0.24	0.67	0.54

1: Summer commercial fishery.
2: Summer commercial fishery, winter commercial fishery and subsistence fishery.

Total retained catch during 2016/17 did not exceed the OFL for this stock, thus overfishing is not occurring. Stock biomass is above MSST; thus, the stock is not overfished.

8 Aleutian Islands Golden King Crab

Fishery information relative to OFL setting

The directed fishery has been prosecuted annually since the 1981/82 season. Retained catch peaked in 1986/87 at 14.7 million lb and averaged 11.9 million lb over the 1985/86-1989/90 seasons. Average harvests dropped sharply from 1989/90 to 1990/91 to a level of 6.9 million lb for the period 1990/91–1995/96. Management based on a formally established GHL began with the 1996/97 season. The 5.9 million lb GHL established for the 1996/97 season, which was based on the previous five-year average catch, was subsequently reduced to 5.7 million lb beginning in 1998/99. The GHL (or TAC, since 2005/06) remained at 5.700 million lb for 2007/08, but was increased to 5.985 million lb for the 2008/09-2011/12 seasons, and to 6.290 million lb starting with the 2012/13 season. The TAC was reduced to 5.545 million lb for the 2016/17 season. This fishery is rationalized under the Crab Rationalization Program.

Non-retained bycatch occurs mainly in the directed fishery, and to a minor extent in other crab fisheries. Bycatch also occurs in fixed-gear and trawl groundfish fisheries although that bycatch is low relative to bycatch in the directed fishery. Total annual non-retained catch of golden king crab during crab fisheries decreased relative to the retained catch after the 1990s. Bycatch in the post-rationalized fishery (2005/06-2016/17) has ranged from 2.5 million lb in 2005/06 (46% of the retained catch) to 3.2 million lb for 2013/14 (50% of the retained catch). Estimated total mortality (retained catch plus bycatch in crab and groundfish fisheries) ranged from 5.8 to 9.4 million lb since 1995/96.

Data and assessment methodology

The assessment for AI golden king crab establishes a single OFL and ABC for the whole stock however separate models are evaluated for EAG and WAG owing to different spatial trends in the fishery. Through the 2016/17 fishing year, the assessment was based on a Tier 5 methodology applied to data from ADF&G fish tickets, size-frequencies from samples of landed crabs, at-sea observations from pot lifts sampled during the fishery, and bycatch estimates from the groundfish fisheries. The modeling framework has been under development for several years, with model assumptions and data inputs refined by reviews by the SSC and CPT. The modeling framework was recommended by the CPT in September 2016 and approved by the SSC in October 2016 for use in the 2017/18 specifications cycle.

The model-based stock assessment involves fitting male-only population dynamics models to data on catches and discards in the directed fishery, discards in the groundfish fishery, standardized indices of abundance based on observer data, fish ticket CPUE data, length-frequency data for the directed fishery (landing and total catch), and mark-recapture data. These data are available through the 2015/16 season.

The assessment author examined 11 model scenarios for this assessment. Model 1 assumed that the proportion mature was a logistic function of length, was fitted to observer CPUE data for 1995/96 – 2015/16 and fish ticket data from 1985/86 to 1998/99, and fixed M for both stocks to be $0.224 yr^{-1}$. Models 2 – 11 varied the assumptions of Model 1 by: omitting the fish ticket data (Model 2), including additional observer CPUE data for 1991/92-1994/95 (Model 3), considering three rather than two selectivity patterns (Model 4), assuming higher and lower values for M (Models 5 and 6), assuming knife-edged maturity at 111 mm CL (Model 9), area-specific values for M (Model 10), and area-specific values of M with knife-edged maturity at 111 mm CL (Model 11). Models 7 and 8 are identical to Model 1, except they consider different definitions for the mean recruitment used to define B_{MSY}. The CPT recommended Model 9 which concurs with the author's recommendation, noting that the data on maturity at length were not reliable enough to estimate a logistic function which forms the basis for models other than Model 9 and 11 but could estimate a knife-edged length at maturity. Model 9 was preferred to Model 11 because the evidence for area differences in M is weak.

This is the only crab assessment that relies solely on fishery CPUE as an index of abundance, with the CPUE index standardization process subject to past CPT and SSC review. The CPT recommended that the model be used to provide management reference points based on the Tier 3 control rule in January 2017 and this tier recommendation was endorsed by the SSC in February 2017.

An industry-ADF&G collaborative survey was implemented for this stock in 2015.

Stock biomass and recruitment trends

Estimated mature male biomass (MMB) for the EAG decreased from high levels until the 1990s after which the trend has been increasing. In contrast, the MMB for WAG increased from a low in the 1990s until 2007/08 and then declined again. Recruitment for the EAG is variable with a generally increasing trend while recruitment for WAG is lower in recent years than during the 1980s. Stock trends reflected the fishery standardized CPUE trends in both areas.

Summary of major changes

The assessment is based on a male-only population dynamics model rather than the Tier 5 methodology. The changes to the assessment from the January 2017 modeling workshop were specification of maturity-at-length and refinement of the proposed models.

Tier determination/Plan Team discussion and resulting OFL and ABC determination

The CPT recommends that this stock be managed as a Tier 3 stock in 2017/18. A single OFL and ABC is defined for AIGKC. However, separate models are available by area. The CPT considered two ways for computing an OFL for AIGKC.

- Apply the OFL control rule by area and sum the OFLs by area.
- Determine stock status for the stock by adding the estimates of current MMB and B_{MSY} by area. This stock status is then used to determine the ratio of F_{OFL} to $F_{35\%}$ by area, which is then used to calculate the OFLs by area which are then added together to calculate an OFL for the entire stock.

The CPT recommended the second alternative because it relies on a single stock status determination rather than for area specific status determinations for the EAG and WAG. In contrast, use of the first alternative would lead to the EAG area being in tier 3a and the WAG area being in tier 3b, which would not result in a unique tier level for the stock. The SSC concurred with this approach.

The CPT recommends that the $B_{MSY\text{proxy}}$ for the Tier 3 harvest control rule be based on the average recruitment from 1987-2012, years for which recruitment is relatively precisely estimated.

Status and catch specifications (1000 t) of Aleutian Islands golden king crab.

Year	MSST	Biomass (MMB)	TAC	Retained Catch [a]	Total Catch[a]	OFL	ABC
2013/14	N/A	N/A	2.853	2.894	3.192	5.69	5.12
2014/15	N/A	N/A	2.853	2.771	3.079	5.69	4.26
2015/16	N/A	N/A	2.853	2.729	3.073	5.69	4.26
2016/17	N/A	N/A	2.515	2.593	2.829	5.69	4.26
2017/18[b]	6.044	14.205				6.048	4.838

a. Total retained catch plus estimated bycatch mortality of discarded bycatch during crab fisheries and groundfish fisheries.
b. Approach 2 above.

Status and catch specifications (million lb) of Aleutian Islands golden king crab.

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch[a]	OFL	ABC
2013/14	N/A	N/A	6.290	6.38	7.04	12.54	11.28
2014/15	N/A	N/A	6.290	6.11	6.79	12.53	9.40
2015/16	N/A	N/A	6.290	6.016	6.78	12.53	9.40
2016/17	N/A	N/A	5.545			12.53	9.40
2017/18[b]	13.325	31.315				13.33	10.67

a. Total retained catch plus estimated bycatch mortality of discarded bycatch during crab fisheries and groundfish fisheries.
b. Approach 2 above.

Overfishing did not occur during 2015/16 because the estimated total catch did not exceed the Tier 5 overfishing limit (OFL) of 12.53-million lb (5.69 kt).

Additional Plan Team recommendations

The CPT recommended that for the next assessment, the assessment author pre-specify the maturity ogive rather than estimating it along with other model parameters, and consider estimating rather the pre-specifying the 1960 recruitment, which would then be used to calculate B_{MSY}. The CPT was informed about analyses to explore the impact of changes to the area fished. Further work was encouraged on this topic, which will help the CPT understand the extent of uncertainty associated with the assessment.

While the CPT recommended the use of the second alternative OFL calculation as listed above, the calculations for the OFL and ABC based upon the first alternative are shown below.

Status and catch specifications (1000 t) of Aleutian Islands golden king crab

Year	MSST	Biomass (MMB)	TAC	Retained Catch[a]	Total Catch[a]	OFL	ABC
2017/18	6.044	14.233				6.018	4.815

Status and catch specifications (million lb) of Aleutian Islands golden king crab

Year	MSST	Biomass (MMB)	TAC	Retained Catch[a]	Total Catch[a]	OFL	ABC
2017/18c	13.325	31.378				13.27	10.61

9 Pribilof District Golden King Crab

Fishery information relative to OFL setting

The Pribilof District golden king crab fishery began in the 1981/82 season, but is currently managed by calendar year. The directed fishery mainly occurs in Pribilof Canyon of the continental slope. Peak directed harvest was 0.856 million lb (388 t) by 50 vessels during the 1983/84 season; fishery participation has since been sporadic and retained catches vary from 0 to 0.342 million lb (155 t). A guideline harvest level (GHL) was first established in 1999 at 0.200 million lb (91 t) and the fishery has been managed with a GHL of 0.150 million lb (68 t) since 2000. No directed fishery occurred during 2006–2009, but one vessel landed catch in 2010, two vessels landed catch in 2011, and one vessel landed catch each year from 2012 to 2014. No vessels participated in the directed fishery during 2015 or 2016. Discarded (non-retained) catch has occurred in the directed golden king crab fishery, the eastern Bering Sea snow crab fishery, the Bering Sea grooved Tanner crab fishery, and in Bering Sea groundfish fisheries. Estimates of annual total fishery mortality during 2001–2016 due to crab fisheries range from 0 0.160 million lb (73 t). There was no discarded catch during crab fisheries in 2016. Estimates of annual fishery mortality during 1991/92–2016 due to groundfish fisheries range from <0.001 to 0.019 million lb (8.84 t). Total fishery mortality in groundfish fisheries during the 2016 crab fishing year was 0.24 t.

Data and assessment methodology

There is no assessment model for this stock. Fish ticket and observer data are available, size-frequency data from samples of landed crabs, and pot lifts sampled during the fishery, and from the groundfish fisheries. Much of the directed fishery data are confidential due to low participation levels. A random effects model using slope survey data was explored; however, the model fit was poor for mature and legal size male, likely due to small number of data points and the high variance.

Stock biomass and recruitment trends

There is no stock biomass data used in this Tier 5 assessment.

Tier determination/Plan Team discussion and resulting OFL and ABC determination

The CPT recommends this stock be managed under Tier 5 in 2018, 2019, and 2020. The CPT concurs with the author's recommended status quo OFL of 0.20 million lb and an ABC of 0.15 million lb. The ABC was derived by applying a 25% buffer of the OFL, ABC = 0.75 * OFL, the same buffer used for other Tier 5 stocks with similar levels of concern. The 2018–2020 OFL calculation is the same as recommended by the SSC for 2012−2017:

$$OFL_{2018–2020} = (1+R_{2001–2010})*RET_{1993-1998} + BM_{NC,1994-1998} + BM_{GF,1992/93–1998/99}$$

where,

- $R_{2001–2010}$ is the average of the estimated annual ratio of lb of bycatch mortality to lb of retained in the directed fishery during 2001–2010.
- $RET_{1993-1998}$ is the average annual retained catch in the directed crab fishery during 1993–1998.
- $BM_{NC,1994-1998}$ is the estimated average annual bycatch mortality in non-directed crab fisheries during 1994–1998.
- $BM_{GF,1992/93–1998/99}$ is the estimated average annual bycatch mortality in groundfish fisheries during 1992/93–1998/99.

Status and catch specifications (t) of Pribilof District golden king crab.

Calendar Year	MSST	Biomass (MMB)	GHL	Retained Catch	Total Catch	OFL	ABC
2013	N/A	N/A	68	Conf.	Conf.	91	82
2014	N/A	N/A	68	Conf.	Conf.	91	82
2015	N/A	N/A	59	0	1.92	91	68
2016	N/A	N/A	59	0	0.24	91	68
2017	N/A	N/A	59			93	70
2018	N/A	N/A				93	70
2019	N/A	N/A				93	70
2020	N/A	N/A				93	70

N/A = not available
Conf. = confidential
TBA = to be announced

Status and catch specifications (millions lb) of Pribilof District golden king crab.

Calendar Year	MSST	Biomass (MMB)	GHL	Retained Catch	Total Catch	OFL	ABC
2013	N/A	N/A	150,000	Conf.	Conf.	0.20	0.18
2014	N/A	N/A	150,000	Conf.	Conf.	0.20	0.18
2015	N/A	N/A	130,000	0	0.004	0.20	0.15
2016	N/A	N/A	130,000	0	<0.001	0.20	0.15
2017	N/A	N/A	130,000			0.20	0.15
2018	N/A	N/A				0.20	0.15
2019	N/A	N/A				0.20	0.15
2020	N/A	N/A				0.20	0.15

N/A = not available
Conf. = confidential
TBA = to be announced

10 Western Aleutian Islands red king crab

Fishery information relative to OFL and ABC setting

The domestic fishery has been prosecuted every season from 1960/61 to 1995/96. During the early years of the fishery through the late 1970s, most or all of the retained catch was harvested in the area between 172° W longitude and 179°15' W longitude. Peak harvest occurred during the 1964/65 season with a retained catch of 21.19 million lb. As the annual retained catch decreased into the mid-1970s and the early-1980s, the area west of 179°15' W longitude began to account for a larger portion of the retained catch. After 1995/96, the fishery was opened only occasionally. There was an exploratory fishery in 1998/99, three commissioner's permit fisheries in limited areas during 2000/01–2002/03 to allow for ADF&G-Industry surveys, and two commercial fisheries with a GHL of 0.5 million lb in 2002/03 and 2003/04 in the Petrel Bank area. The fishery has been closed since 2003/04.

Retained catch from 1985/86 to 1994/95 averaged 0.94 million lb, but the retained catch during the 1995/96 season dropped to 0.04 million lb. Most of the catch since the 1990/91 season was harvested in the Petrel Bank area (between 179° W longitude and 179° E longitude) and the last two commercial fishery seasons were opened only in the Petrel Bank area with 0.51 million lb in 2002/03 and 0.48 million lb in 2003/04. Non-retained catch of red king crabs occurs in both the directed red king crab fishery, the Aleutian Islands golden king crab fishery, and in groundfish fisheries. Estimated bycatch mortality in the crab fisheries during the 1995/96 to 2015/16 seasons averaged 0.002 million lb in crab fisheries and 0.020 million lb in groundfish fisheries. Estimated annual total fishing mortality from 1995/96 to 2015/16 averaged 0.079 million lb. The average retained catch during that period was 0.060 million lb. This fishery is rationalized under the Crab Rationalization Program only for the area west of 179° W longitude.

Data and assessment methodology

The 1960/61 to 2007/08 time series of retained catch (number and pounds of crabs), effort (vessels, landings and pot lifts), average weight and average carapace length of landed crabs, and catch-per-unit effort (number of crabs per pot lift) are available. Bycatch from crab fisheries from 1995/96 to 2016/17 and from groundfish fisheries from 1993/94 to 2016/17 are available. There is no assessment model for this stock. The standardized surveys of the Petrel Bank area conducted by ADF&G in 2006 and 2009 and the ADF&G-Industry Petrel Bank surveys conducted in 2001 were too limited in geographic scope and too infrequent for reliable estimation of abundance for the entire western Aleutian Islands area.

Stock biomass and recruitment trends

Estimates of stock biomass, recruitment trends, and current levels relative to virgin or historic levels are not available for this stock. The fishery has been closed since 2003/04 due to apparent poor recruitment. A 2009 survey conducted by ADF&G in the Petrel Bank area encountered an ageing population of legal male crab occurring in a more limited area and at lower densities than were found in a 2006 survey and provided no expectations for recruitment. A test fishery conducted by a commercial vessel during October-December 2009 in the area west of Petrel Bank yielded only one legal male red king crab. A cooperative red king crab survey was performed by the Aleutian Islands King Crab Foundation and ADF&G in the Petrel Bank area in November 2016 averaged less than one crab per pot lift suggesting that the stock is in poor condition.

Tier determination/Plan Team discussion and resulting OFL and ABC determination

The CPT recommends that this stock be managed under Tier 5 for the 2017/18, 2018/19, and 2019/20 seasons. The CPT concurs with the assessment author's recommendation of an OFL based on the 1995/96–2007/08 average total catch following the recommendation of the SSC in June 2010 to set the time period for computing the OFL at 1995/96–2007/08. The CPT recommends an OFL for 2017/18 to 2019/20 of 0.123867 million lb.

The CPT continues to have concerns regarding the depleted condition of this stock. Groundfish bycatch in recent years has accounted for the majority of the total catch. The CPT recommends an ABC of 0.030967 million lb for 2017/18, 2018/19, and 2019/20 which is equivalent to a 75% buffer on OFL. The recommended ABC is less than that which was recommended by the SSC for 2012/13–2016/17 because 1) the industry has not expressed interest in a small test fishery, and 2) because the stock is severely depressed as indicated by the 2016 Petrel survey (CPT minutes for May 2017).

Status and catch specifications t of Western Aleutian Islands red king crab.

Fishing Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2013/14	N/A	N/A	Closed	0	<1	56	34
2014/15	N/A	N/A	Closed	0	<1	56	34
2015/16	N/A	N/A	Closed	0	1.3	56	34
2016/17	N/A	N/A	Closed	0	<1	56	34
2017/18	N/A	N/A				56	14
2018/19	N/A	N/A				56	14
2019/20	N/A	N/A				56	14

Status and catch specifications (million lb) of Western Aleutian Islands red king crab.

Fishing Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2013/14	N/A	N/A	Closed	0	0.00073	0.124	0.074
2014/15	N/A	N/A	Closed	0	0.00047	0.124	0.074
2015/16	N/A	N/A	Closed	0	0.00296	0.124	0.074
2016/17	N/A	N/A	Closed	0	0.00045	0.124	0.074
2017/18	N/A	N/A				0.124	0.074
2018/19	N/A	N/A				0.124	0.074
2019/20	N/A	N/A				0.124	0.074

Figures and Tables

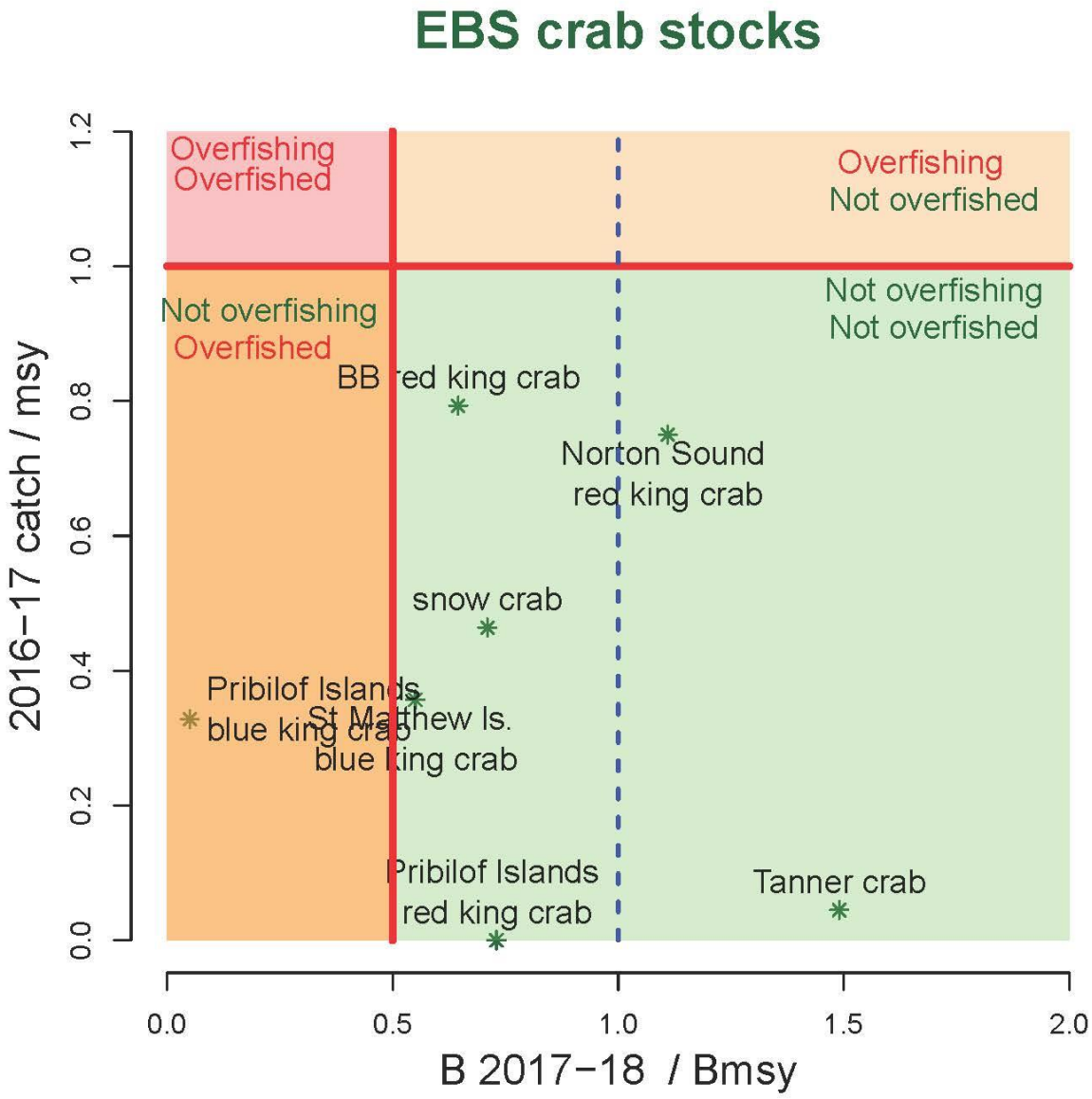

Figure 1. Status of 7 Bering Sea crab stocks in relation to status determination criteria (B_{MSY}, MSST, overfishing). Note that information is insufficient to assess Tier 5 stocks according to these criteria (WAIRKC, AIGKC, PIGKC).

Table 3. Crab Plan Team recommendations for September 2017. Note that recommendations for stocks 7, 8, 9, 10 represent those final values recommended by the SSC in February and June 2017. (Note: diagonal fill indicates parameters are not applicable for that tier.) Biomass units are 1000 t.

Chapter	Stock	Tier	Status (a,b,c)	F_{OFL}	B_{MSY} or $B_{MSY\ proxy}$	Years[1] (biomass or catch)	2017/18[2] MMB	2017/18 MMB / MMB_{MSY}	γ	Mortality (M)	2017/18[3] OFL	2017/18 ABC	ABC Buffer
1	EBS snow crab	3		0.89	139.4	1979-current [recruitment]	99.6	0.71		0.23(females) 0.417 (imm) 0.259 (mat males)	28.41	25.6	20%
2	BB red king crab	3	b	0.24	25.1	1984-current [recruitment]	21.31	0.85		0.18 default; estimated	5.6	5.04	10%
3	EBS Tanner crab	3	b	0.75	29.17	1982-current	43.31	1.49		0.34 (females), 0.25 (mat male), 0.247 (imm males and female	25.42	20.33	10%
4	Pribilof Islands red king crab	4	a	0.18	4.6	1991/92-2016/17	3.36	0.73	1	0.18	0.48	0.36	20%
5	Pribilof Islands blue king crab	4	c	0.18	4.11	1980/81-1984/85 & 1990/91-1997/98	0.23	0.05	1	0.18	0.00116	0.00087	25%
6	St. Matthew Island blue king crab	4	b	0.079	3.93	1978-current	2.18	0.55	1	0.18	0.12	0.09	20%
7	Norton Sound red king crab	4	a	0.18	2.1	1980-current	2.33	1.11	1	0.18	0.3	0.24	20%
8	AI golden king crab	3	a	EAG (0.75) WAG (0.68)	12.09	1987/88-2012/13	14.21	1.17		0.22	6.05	4.54	25%
9	Pribilof Islands golden king crab	5				See intro chapter					0.09	0.07	25%
10	Western AI red king crab	5				1995/96-2007/08					0.06	0.01	75%

[1] For Tiers 3 and 4 where B_{MSY} or $B_{MSYproxy}$ is estimable, the years refer to the time period over which the estimate is made. For Tier 5 stocks it is the years upon which the catch average for OFL is obtained. **[2]** MMB as projected for 2/1/2017 for Norton Sound red king crab, 2/15/2017 for AIGKC, and 2/15/2018 for other stocks. **[3]** AIGKC OFL and ABC calculated by author outside the chapter for using the Approach 2 combination of EAG and WAG and 25% buffer between OFL and ABC. **[4]** Additional mortality males: two periods-1980-1985; 1968-1979 and 1986-2013. Females three periods: 1980-1984; 1976-1979; 1985 to 1993 and 1968-1975; 1994-2013. See assessment for mortality rates associated with these time periods.

Table 4. Maximum permissible ABCs for 2017/18[1] and Crab Plan Team recommended ABCs for those stocks where the Plan Team recommendation is below the maximum permissible ABC[2] as defined by Amendment 38 to the Crab FMP. Note that the rationale is provided in the individual introduction chapters for recommending an ABC less than the maximum permissible for these stocks.

Stock	Tier	2016/17 *Max*ABC (1000 t)	2016/17 ABC (1000 t)
EBS Snow Crab	3	28.4	25.6
Bristol Bay red king crab	3	5.6	5.04
EBS Tanner Crab	3	25.57	20.33
Pribilof Islands red king crab	4	0.39	0.36
Pribilof Islands blue king crab	4	0.00116	0.00087
Saint Matthew blue king crab	4	0.12	0.09
Norton Sound red king crab	4	0.3	0.24
Aleutian Islands golden king crab	3	6.02	4.54
Pribilof Islands golden king crab[1]	5	0.08	0.07
WAI red king crab	5	0.05	0.01

[1] For Pribilof Islands golden king crab, this is for the 2018 calendar year instead of the 2017-2018 crab fishing year.

[2] For Tier 5 stocks this is 0.90 while all other stocks P*.

Table 5. Stock status in relation to status determination criteria for 2016/17 as estimated in September 2017. (Note: shaded portion indicates parameters not applicable for this tier level).

Chapter	Stock	Tier	MSST	B_{MSY} or $B_{MSYproxy}$	2015/16 [1] MMB	2016/17 MMB / MMB_{MSY}	2016/17 OFL 1000 t	2016/17 Total catch	Rebuilding Status
1	EBS snow crab	3	78.9	157.8	208.1	1.32	83.1	24.3	
2	BB red king crab	3	13.05	26.1	25.8	0.99	6.73	4.28	
3	EBS Tanner crab	3	13.4	26.8	77.96	2.91	27.18	1.14	
4	Pribilof Islands red king crab	4	2.83	5.65	4.79	0.85	1.36	0.49	
5	Pribilof Islands blue king crab	4	2.05	4.1	0.23	0.06	1.16	0.00038	overfished
6	St. Matthew Island blue king crab	4	1.86	3.72	2.23	0.60	0.28	0.05	
7	Norton Sound red king crab	4	1.03	2.06	1.9	1.29	0.32	0.24	
8	Aleutian Islands golden king crab	5							
9	Pribilof Islands golden king crab	5							
10	Adak red king crab	5							

1-For stocks 1-6 MMB on 2/15/2016 is estimated using the current assessment in September 2016. For Norton Sound red king crab MMB on 2/1/2016 is estimated using the current assessment in January 2017.